NOx Control Cost Effectiveness Estimate

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Engine Manufacturer	General Electric			
Model No. Unit ID	LM 1600 12A			
Fuel Used	Natural Gas			Color Legend
Emissions Control	SCR			User Data / Information Input Cell
Combustion Control Purpose Target Reduction	NOx 75%			"Cumulative" Cost Cell for Primary Categories Cost Effectiveness (\$ / ton)
Engine Design Conditions	1070	=		Comments
Power Output	19200	(hp)		Rated HP
Engine Exhaust Temperature		(F)		optional input
Engine Exhaust Rate Gas Volume		(lb/hr) (dscfm)		optional input optional input
ull Load Engine Exhaust Composition:				Comments
Oxygen (O ₂₎		(vol. %)	1	optional input
Carbon Dioxide (CO ₂₎		(vol. %)		optional input
Water (H ₂ O)		(vol. %)		optional input
Oxides of Nitrogen (NOx)		(ppmvd)		optional input
Nitrogen (N ₂₎		(vol. %)		optional input
NOx	52.	.7 lb/hr 0.366	(lb/MMBtu)	NOx emissions from test Data: 373.0 lb/MMSCF ~0.37 lb/MMBtr
ngine Parameters	0700	1/1	er e	Comments
Total Operating Hours per Season	8760	(hrs) 100%	utilization	
inal Exhaust Gas Composition				Comments
Oxides of Nitrogen (NOx)	13.	.2 lb/hr 0.092	(lb/MMBtu)	Assume 75% reduction
conomic Parameters				Comments
Source of Cost Data	see Analysis		•	Analysis primarily relying on EPA Cost Manual
lirect Costs		Cost Formula		Comments
Combustion Control Equipment and Auxiliary	\$3,712,500	(4)		Based on EPA control cost manual (\$167/kw; adjust to 2020\$)
Equipment Instrumentation		(A) (0.1*A)		
Instrumentation Sales Taxes	\$371,250 \$0	(0.1°A) (0.03*(A+instrumentation))		Calculated Cost using EPA Control Cost Manual No Oregon sales tax
Freight	\$185,625	(0.05*A)	_	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	\$4,269,375	PEC		
Direct Installation Costs		Cost Formula		Comments
Foundations and Supports	\$341,550	(0.08*PEC)		Calculated Cost using EPA Control Cost Manual
Handling and Erection Electrical	\$597,710 \$170,780	(0.14*PEC) (0.04*PEC)		Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Piping	\$85,390	(0.02*PEC)		Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	\$42,690	(0.01*PEC)		Calculated Cost using EPA Control Cost Manual
Painting Site Preparation	\$42,690 \$0	(0.01*PEC) SP		Calculated Cost using EPA Control Cost Manual Cost included with next row
Buildings	\$235,000	Bldg		Quote for piping rerouting, etc. to accommodate retrofit
Total Installation Cost (TIC)	\$1,515,810			
Total Direct Costs (PEC+TIC)	\$5,785,185		ĺ	
ndirect Costs		Cost Formula		Comments
Engineering	\$426,938	(0.10*PEC)		Calculated Cost using EPA Control Cost Manual
Construction and field expenses Contractor fees	\$213,469 \$426,938	(0.05*PEC) (0.10*PEC)		Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Start-up	\$85,388	(0.02*PEC)		Calculated Cost using EPA Control Cost Manual
Performance test	\$42,694	(0.01*PEC)		Calculated Cost using EPA Control Cost Manual
Contingencies Total Indirect Costs (IC)	\$128,081 \$1,323,506	(0.03*PEC) (0.31*PEC)		Calculated Cost using EPA Control Cost Manual
. ,	φ1,323,300	(0.31 FEG)		
Capital Cost Summary	A			Comments
Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC)	\$5,785,185 \$1,323,506			
Total Capital Investment (TCI)	\$7,108,691		!	<u> </u>
Operator Labor	\$26,000	Cost Formula Inominal cost	1	Comments 5 hours per week (1 hr x 5 days); job category labor rate
Operator Labor Supervisor Labor	\$3,900	nominal cost		5 nours per week (1 nr x 5 days); job category labor rate 15% of operator
Operating Materials - ammonia	\$54,289			materials estimate annual NH3 at \$700 per ton; 1.1 molar ratio
Maintenance - Labor	\$26,000	nominal cost		5 hours per week (1 hr x 5 days); job category labor rate
Maintenance - Materials Catalyst maintenance / replacement	\$5,000 \$185,625	nominal cost		Engineering Estimate Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	\$20,000			Engineering estimate - Annual test; reagent controller QA
Electricity	\$2,500			Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	\$323,314		_	
ndirect Annual Costs	600 510		covery Factor	Comments
Overhead Administrative Charges	\$36,540 \$142,174	(0.6*(OL+SL+ML+MM)) (0.02*TCI)		Engine ACT Document
Property Taxes	\$71,087	(0.01*TCI)		Engine ACT Document
Insurance	\$71,087 \$374,628	(0.01*TCI)	CRF 0.0527	Eactor for costs applications over 20 years at 2 250/ interest
Capital Recovery Total Indirect Annual Costs	\$374,628 \$695,516	CRF[TCI]		Factor for costs annualized over 30 years at 3.25% interest. RF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% =
	7000,010		O.	, , , , , , , , , , , , , , , , , , , ,
Summary	4000 011			Comments
Fotal Direct Annual Operating Costs Fotal Indirect Annual Operating Costs	\$323,314 \$695,516			
Total Annual Costs	\$1,018,830	\$53	\$ per hp	
ncremental Annual Costs Over Baseline	\$1,018,830			
Annual Emissions Reduction Over Baseline	_ 			Comments
Oxides of Nitrogen (NOx)	173.1	3 (Tons)		Somments
Cost Effectiveness (\$/Ton)		OE .		Comments
Oxides of Nitrogen (NOx)	\$5,88 \$11,456		e annually)	PSEL basis: significantly over-estimates utilization
		at 50% utilization (4,380 hour at 2017-2019 average utilizat		

NOx Control Cost Effectiveness Estimate

Model No. Unit ID	Avon 12B		
Fuel Used	Natural Gas		Color Legend
Emissions Control	SCR		User Data / Information Input Cell
Combustion Control Purpose Target Reduction	NOx 75%		"Cumulative" Cost Cell for Primary Categories Cost Effectiveness (\$ / ton)
Engine Design Conditions	1070		Comments
Power Output	14300	(hp)	Rated HP
Engine Exhaust Temperature		(F)	optional input
Engine Exhaust Rate Gas Volume		(lb/hr) (dscfm)	optional input optional input
Full Load Engine Exhaust Composition:			Comments
Oxygen (O ₂₎		(vol. %)	optional input
Carbon Dioxide (CO ₂₎		(vol. %)	optional input
Water (H ₂ O)		(vol. %)	optional input
Oxides of Nitrogen (NOx) Nitrogen (N ₂₎		(ppmvd)	optional input
NOx	23	(vol. %) 3.1 lb/hr 0.170 (lb/MMBtu)	optional input NOx emissions from test Data: 173.9 lb/MMSCF ~0.170 lb/MME
Ingine Parameters Total Operating Hours per Season	8760	(hrs) 100% utilization	Comments
	0,00	(iiio)	0
inal Exhaust Gas Composition Oxides of Nitrogen (NOx)	ŗ	5.8 lb/hr 0.043 (lb/MMBtu)	Comments Assume 75% reduction
conomic Parameters		o.o.o (Diministra)	Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual
Direct Costs		Cost Formula	Comments
Combustion Control Equipment and Auxiliary	\$2.765.000		
Equipment	\$2,765,000	(A)	Based on EPA control cost manual (\$167/kw; adjust to 2020\$)
Instrumentation Sales Taxes	\$276,500 \$0	(0.1*A) (0.03*(A+instrumentation))	Calculated Cost using EPA Control Cost Manual No Oregon sales tax
Freight	\$138,250	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	\$3,179,750	PEC	
Direct Installation Costs		Cost Formula	Comments
Foundations and Supports Handling and Erection	\$254,380 \$445,170	(0.08*PEC) (0.14*PEC)	Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Electrical	\$127,190	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping Insulation for ductwork	\$63,600 \$31,800	(0.02*PEC) (0.01*PEC)	Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Painting	\$31,800	(0.01 FEC) (0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	\$0	SP	Cost included with next row
Buildings Total Installation Cost (TIC)	\$1,035,000 \$1,988,940	Bldg	Quote for major reconstruction to accommodate retrofit
Total Direct Costs (PEC+TIC)	\$5,168,690	_	I
Indirect Costs	ψο, 100,000	Cost Formula	l Comments
Engineering	\$317,975	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	\$158,988	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	\$317,975 \$63,595	(0.10*PEC) (0.02*PEC)	Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Start-up	\$31,798	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test		(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test Contingencies	\$95,393 \$985,723	(0.31*PFC)	
Performance test Contingencies Total Indirect Costs (IC)	\$95,393 \$985,723	(0.31*PEC)	
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary	\$985,723	(0.31*PEC)	Comments
Performance test Contingencies Total Indirect Costs (IC)		(0.31*PEC)	Comments
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC)	\$985,723 \$5,168,690	(0.31*PEC)	Comments
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI)	\$985,723 \$5,168,690 \$985,723	(0.31*PEC) Cost Formula	Comments
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000		Comments 5 hours per week (1 hr x 5 days); job category labor rate
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900	Cost Formula	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000	Cost Formula	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000	Cost Formula nominal cost	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250	Cost Formula nominal cost	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$138,250 \$20,000 \$2,500	Cost Formula nominal cost	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost)
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000	Cost Formula nominal cost	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rate 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA
Performance test Contingencies Total Indirect Costs (IC) Total Direct Capital Costs (DC) Total Indirect Capital Costs (DC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs ndirect Annual Costs	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$323,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439	Cost Formula nominal cost nominal cost nominal cost Cost Formula Capital Recovery Factor	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA
Performance test Contingencies Total Indirect Costs (IC) Capital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Indirect Annual Costs Overhead	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439	Cost Formula nominal cost nominal cost nominal cost Cost Formula Capital Recovery Factor (0.6*(OL+SL+ML+MM))	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs ndirect Annual Costs Overhead Administrative Charges Property Taxes	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$2,500 \$22,500 \$245,439 \$36,540 \$123,088 \$61,544	Cost Formula nominal cost nominal	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD
Performance test Contingencies Total Indirect Costs (IC) Zapital Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Overhead Administrative Charges Property Taxes Insurance	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$138,250 \$20,000 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$61,544	Cost Formula nominal cost nominal	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs ndirect Annual Costs Overhead Administrative Charges Property Taxes	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$2,500 \$22,500 \$245,439 \$36,540 \$123,088 \$61,544	Cost Formula nominal cost cost Formula Capital Recovery Factor (0.6*(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest.
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Supervisor Labor Operating Materials - ammonia Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$31,544 \$324,338	Cost Formula nominal cost cost Formula Capital Recovery Factor (0.6*(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. Factor for costs annualized over 30 years at 3.25% interest.
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Indirect Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Summary	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$324,338 \$607,054	Cost Formula nominal cost cost Formula Capital Recovery Factor (0.6*(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest.
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Summary Fotal Direct Annual Costs Overhead Capital Recovery Total Indirect Annual Costs Summary Fotal Direct Annual Operating Costs Fotal Direct Annual Operating Costs Fotal Indirect Annual Operating Costs	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$33,900 \$5,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$61,544 \$324,338 \$607,054	Cost Formula nominal cost Cost Formula Capital Recovery Factor (0.6"(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527 CF	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. Factor for costs annualized over 30 years at 3.25% interest.
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Summary Total Indirect Annual Costs Summary Total Indirect Annual Costs Total Indirect Annual Costs Total Indirect Annual Costs Summary Total Indirect Annual Costs	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$324,338 \$607,054	Cost Formula nominal cost cost Formula Capital Recovery Factor (0.6*(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. Factor for costs annualized over 30 years at 3.25% interest.
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs ndirect Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Summary Total Direct Annual Costs Overhead Total Direct Annual Costs Overhead Capital Recovery Total Indirect Annual Costs Summary Total Direct Annual Operating Costs Total Indirect Annual Costs Total Indirect Annual Costs Total Costs Total Annual Costs Total Annual Costs Total Annual Costs Total Annual Costs Total Costs Total Annual Costs Total Annual Costs Total Annual Costs Total Costs Total Annual Costs Total Annual Costs Total Costs Total Annual Costs Total Costs Total Annual Costs Total Cost	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$33,900 \$5,000 \$5,000 \$138,250 \$20,000 \$2,500 \$245,439 \$36,540 \$123,088 \$61,544 \$61,544 \$324,338 \$607,054	Cost Formula nominal cost Cost Formula Capital Recovery Factor (0.6"(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527 CF	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. RF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = Comments
Performance test Contingencies Total Indirect Costs (IC) Total Cost Summary Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Indirect Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Summary Total Direct Annual Costs Total Direct Annual Costs Total Indirect Annual Costs Summary Total Direct Annual Operating Costs Total Indirect Annual Costs Total Indirect Annual Costs Total Indirect Annual Operating Costs Total Indirect Annual Costs Total Capital Costs Total Annual Costs Total Capital Costs Total Annual Costs Total Capital Cos	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$2,500 \$2,500 \$245,439 \$36,540 \$11,544 \$3	Cost Formula nominal cost nominal cost nominal cost nominal cost nominal cost cost Formula Capital Recovery Factor (0.6°(OL+SL+ML+MM)) (0.02°TCI) (0.01°TCI) CRF CRF[TCI] 0.0527 CF	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar ratis 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. RF = i*(1+i)^n/[(1+i)^n - 1] (i expressed as a decimal - e.g., 10% =
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Operator Labor Supervisor Labor Supervisor Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Performance - Materials Catalyst maintenance - Performance - Materials Catalyst maintenance - Performance - Performa	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$2,500 \$2,500 \$245,439 \$36,540 \$11,544 \$3	Cost Formula nominal cost Cost Formula Capital Recovery Factor (0.6"(OL+SL+ML+MM)) (0.02*TCI) (0.01*TCI) CRF CRF[TCI] 0.0527 CF	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar ratishours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. RF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = Comments
Performance test Contingencies Total Indirect Costs (IC) Total Indirect Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Indirect Capital Costs (IC) Total Capital Investment (TCI) Direct Annual Costs Operator Labor Supervisor Labor Operating Materials - ammonia Maintenance - Labor Maintenance - Materials Catalyst maintenance / replacement Testing and QA/QC Electricity Total Direct Annual Costs Overhead Administrative Charges Property Taxes Insurance Capital Recovery Total Indirect Annual Costs Total Direct Annual Costs Summary Total Indirect Annual Costs Total Direct Annual Costs Total Indirect Annual Costs Total Indirect Annual Operating Costs Total Indirect Annual Costs Total Annual Costs Total Costs	\$985,723 \$5,168,690 \$985,723 \$6,154,413 \$26,000 \$3,900 \$3,900 \$23,789 \$26,000 \$5,000 \$138,250 \$20,000 \$2,500 \$2,500 \$2,500 \$245,439 \$36,540 \$11,544 \$3	Cost Formula nominal cost Cost Formula Capital Recovery Factor (0.0**CI) Capital Recovery Factor (0.0**TCI) CRF CRF[TCI] 0.0527 CF \$60 \$ per hp	Comments 5 hours per week (1 hr x 5 days); job category labor rate 15% of operator materials estimate annual NH3 at \$700 per ton; 1.1 molar rati 5 hours per week (1 hr x 5 days); job category labor rate Engineering Estimate Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA Estimate based on analysis in PA DEP TSD Comments Engine ACT Document Engine ACT Document Engine ACT Document Factor for costs annualized over 30 years at 3.25% interest. RF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = Comments

NOx Control Cost Effectiveness Estimate

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Engine Manufacturer	Solar			
Model No.	Titan			
Unit ID Fuel Used	12C Natural Gas			Color Legend
Emissions Control	SCR			User Data / Information Input Cell
Combustion Control Purpose	NOx			"Cumulative" Cost Cell for Primary Categories
Target Reduction	60%			Cost Effectiveness (\$ / ton)
Engine Design Conditions				Comments
Power Output	19500	(hp)		Rated HP
Engine Exhaust Temperature		(F)		optional input
Engine Exhaust Rate		(lb/hr)		optional input
Gas Volume		(dscfm)		optional input
Full Load Engine Exhaust Composition:				Comments
Oxygen (O ₂₎		(vol. %)		optional input
Carbon Dioxide (CO ₂₎		(vol. %)		optional input
Water (H₂O)		(vol. %)		optional input
Oxides of Nitrogen (NOx)		(ppmvd)		optional input
Nitrogen (N ₂₎		(vol. %)		optional input
NOx		6.8 lb/hr	0.052 (lb/MMBtu)	NOx emissions from test Data: 52.6 lb/MMSCF ~0.052 lb/MMBt
Engine Parameters				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	Comments
Final Exhaust Gas Composition				Comments
Oxides of Nitrogen (NOx)		2.7 lb/hr	0.021 (lb/MMBtu)	Assume 60% reduction for unit equipped with DLE combustion
Economic Parameters			· · ·	Comments
Source of Cost Data	see Analysis			Analysis primarily relying on EPA Cost Manual
Direct Costs		Cost Formula		Comments
Combustion Control Equipment and Auxiliary		COST FORMULA		
Equipment	\$3,770,500	(A)		Based on EPA control cost manual (\$167/kw; adjust to 2020\$)
Instrumentation	\$377,050	(0.1*A)		Calculated Cost using EPA Control Cost Manual
Sales Taxes	\$0	(0.03*(A+instrumenta	ation))	No Oregon sales tax
Freight	\$188,525	(0.05*A)		Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	\$4,336,075	PEC		
Direct Installation Costs		Cost Formula		Comments
Foundations and Supports	\$346,890	(0.08*PEC)		Calculated Cost using EPA Control Cost Manual
Handling and Erection	\$607,050	(0.14*PEC)		Calculated Cost using EPA Control Cost Manual
Electrical	\$173,440	(0.04*PEC)		Calculated Cost using EPA Control Cost Manual
Piping Insulation for ductwork	\$86,720 \$43,360	(0.02*PEC) (0.01*PEC)		Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Painting	\$43,360	(0.01*PEC)		Calculated Cost using EPA Control Cost Manual
Site Preparation	\$0	SP		As required
Buildings	\$0	Bldg		Not considered (initial iteration - \$ per ton are high for this unit)
Total Installation Cost (TIC)	\$1,300,820		·	n
Total Direct Costs (PEC+TIC)	\$5,636,895			
ndirect Costs	# 400.000	Cost Formula		Comments
Engineering Construction and field expenses	\$433,608 \$216,804	(0.10*PEC) (0.05*PEC)		Calculated Cost using EPA Control Cost Manual Calculated Cost using EPA Control Cost Manual
Contractor fees	\$433,608	(0.10*PEC)		Calculated Cost using EPA Control Cost Manual
Start-up	\$86,722	(0.02*PEC)		Calculated Cost using EPA Control Cost Manual
Performance test	\$43,361	(0.01*PEC)		Calculated Cost using EPA Control Cost Manual
Contingencies	\$130,082	(0.03*PEC)		Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	\$1,344,183	(0.31*PEC)		
apital Cost Summary				Comments
Total Direct Capital Costs (DC) Total Indirect Capital Costs (IC)	\$5,636,895 \$1,344,183			
Total Capital Investment (TCI)	\$6,981,078			<u> </u>
Direct Annual Costs		Cost Formula		Comments
Operator Labor	\$26,000	nominal cost		5 hours per week (1 hr x 5 days); job category labor rate
Supervisor Labor	\$3,900			15% of operator
Operating Materials - ammonia	\$7,045			materials estimate annual NH3 at \$700 per ton; 1.1 molar ratio
Maintenance - Labor	\$26,000	nominal cost		5 hours per week (1 hr x 5 days); job category labor rate
Maintenance - Materials	\$5,000	nominal cost		Engineering Estimate
Catalyst maintenance / replacement Testing and QA/QC	\$188,525 \$20,000			Engineering Estimate (5% of Cap Cost) Engineering estimate - Annual test; reagent controller QA
Electricity	\$2,500			Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	\$278,970			
ndirect Annual Costs		Cost Formula Ca	pital Recovery Factor	Comments
Overhead	\$36,540	(0.6*(OL+SL+ML+M	M))	
Administrative Charges	\$139,622	(0.02*TCI)		Engine ACT Document
Property Taxes Insurance	\$69,811 \$69,811	(0.01*TCI) (0.01*TCI)	CRF	Engine ACT Document
Capital Recovery	\$367,903	CRF[TCI]	0.0527	Factor for costs annualized over 30 years at 3.25% interest.
Total Indirect Annual Costs	\$683,686	2 - 3		RF = i * $(1+i)^n / [(1+i)^n - 1]$ (i expressed as a decimal - e.g., 10% =
ummanı		-		Comments
otal Direct Annual Operating Costs	\$278,970		1	Comments
otal Direct Annual Operating Costs otal Indirect Annual Operating Costs	\$278,970 \$683,686			
otal Indirect Affidal Operating Costs otal Annual Costs	\$962,656		\$49 \$ per hp	
ncremental Annual Costs Over Baseline	\$962,656			
Annual Emissions Reduction Over Baseline	·			Comments
Oxides of Nitrogen (NOx)	17	.97 (Tons)		Comments
Oxides of Hillogell (NOX)	17	(10110)		<u>IL</u>
ost Effectiveness (\$/Ton)				Comments
Oxides of Nitrogen (NOx)	\$53,	559		